study of the tropisms, and we find him declaring that it is almost impossible to describe the behaviour of the unicellulars intelligibly without using terms like "perception," "discrimination," and "intelligence." Of course these are used in an "objective sense," and "when their objective significance is kept in mind there is no theoretical objection to them, and they have the advantage that they bring out the identity of the objective factors in the behaviour of animals with the objective factors in the behaviour of man."

From our point of view, Prof. Jennings does not strengthen his position by using these pre-occupied psychological terms; "'perception' of a stimulus," he says, "means merely that the organism reacts to it in some way; 'discrimination' of two stimuli means that the organism reacts differently to them; 'intelligence' is defined by the objective manifestations mentioned in the text." But this does not seem to us the sound line of progress; it leads back to saying that the lucifer match perceives the sandpaper on the box. It seems safer, in the meantime, to say that infusorians alter their behaviour, and alter it effectively, in respect to their experience.

"Stentor does not continue reacting strongly to a stimulus that is not injurious, but after a time, when such stimulus is repeated, it ceases to react, or reacts in some less pronounced way than at first. To an injurious stimulus, on the other hand, it does continue to react, but not throughout in the same manner. When such stimulus is repeated, Stentor tries various different ways of reacting to it. If the result of reacting by bending to one side is not success, it tries reversing the ciliary current, then contracting into its tube, then leaving its tube, &c. This is clearly the method of trial and error passing into the method of intelligence, but the intelligence lasts only very short periods."

With such difficult subjects any evidence of the registration of experience was not to be expected, and the author is to be congratulated on having discovered considerable evidence in support of the thesis that the behaviour of unicellulars is largely a method of trial and error, one reaction by trial and error becoming the basis for a succeeding reaction. This is surely a pathway leading to the high-road of intelligence.

It is easy to make an inanimate system—a little potassium pill on a basin of water, or a tiny wound-up engine on a smooth table—which, once set a-going, will charge against an obstacle, will fail to overcome this, will recoil passively and charge again, and some observers have thought that, *mutatis mutandis,* the animalcule did little more. But Prof. Jennings has shown that the infusorian, in relation to its experience of "error," changes its little tactics, and changes them again, until it succeeds. In a word, it profits by experience. The very essence of vitality, as Spencer pointed out, is in effective response to environment; but when we find an infusorian "trying" one response after another, abandoning those that spell "error," we cannot but feel that vitality has been raised to a second power; it is just beginning to be intelligent. The infusorian is more than a tropic automaton, it is playing a little game of tactics; perhaps if we could educate one it would develop the rudiments of strategy. It is, of course, extremely difficult to keep to a scrupulous objective record of what occurs, but we incline to think that Prof. Jennings has supplied what comparative psychologists have been waiting for, namely, quite trustworthy accounts of the beginnings of selective or controlled behaviour.

"The method of trial and error involves some way of distinguishing error, and also, in some cases at least, some method of distinguishing success. The problem as to how this is done is the same for man and for the infusorian. We are compelled to postulate throughout the series certain physiological states to account for the negative reactions under error, and the positive reactions under success. In man these physiological states are those conditioning pain and pleasure. The 'method of trial and error' is evidently the same as reaction by 'selection of overproduced movements,' which plays so large a part in the theories of Spencer and Bain, and especially in the recent discussions of behaviour by J. Mark Baldwin. The method of trial and error, which forms the most essential feature of the behaviour of these lower organisms, is in complete contrast with the tropism schema, which has long been supposed to express the essential characteristics of their behaviour."

Instead of referring in detail to the author's studies—(1) reactions to heat and cold in the ciliate infusorians; (2) reactions to light in ciliates and flagellates; (3) reactions to stimuli in certain rotifers; (4) the theory of tropisms; (5) physiological states as determining factors in the behaviour of lower organisms; and (6) the movements and reactions of amœbæ—we have sought to explain the chief result of his studies in the infant school of life, and to emphasise its importance in relation to the general theory of animal behaviour. Prof. Jennings has rescued the animalculæ from the bonds of automatism too hurriedly thrust on them, and has afforded a secure basis for the study of the evolution of intelligence.

J. A. T.

MECHANISM.

Mechanism. By Prof. S. Dunkerley. Pp. vi+408. (London: Longmans, Green and Co., 1905.) Price 9*s.* net.

WRITERS of text-books on mechanism have, of late years, been much influenced by the views of Realeaux on the classification of mechanisms, and the present work shows clearly the impress of these views; but the author has not hesitated to depart from the order in which Realeaux presented his theory of machines in order to suit the needs of beginners, who are apt to find the elaboration of the systematic theory somewhat dry if not accompanied by a wealth of illustration drawn from actual machines, even if these contain elements the properties of which have not been fully explained.

The author, as appears from his preface, is fully alive to the difficulties which the logical treatment of the subject presents, and he expressly states that his work is not intended to be a philosophical treatise on the subject.

From this standpoint the arrangement of the sub-

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ject-matter appears to be quite a proper one, for at the present time almost everyone is familiar with the elementary properties of gear-wheels, clutches, the mechanism of steam engines and the like, because of their increasing use in everyday life, and more especially of late, owing to their applications to self-propelled vehicles. On the other hand their less obvious, although not less important, properties are possibly not so well understood; thus, to take a single instance, the conditions to be satisfied in order to produce true rolling motion by gear wheels require a knowledge of the properties of various curves, and this latter subject may well be left to a later stage, as is done in the present work, although it need not prevent a study of machines containing gear wheels when this knowledge is not absolutely necessary for the purpose. The author has therefore described many machines using higher pairing quite early in the book, and has left the more detailed examination of some of the elements for later chapters; this adds very much to the general interest of the reader, while its drawbacks are small. The work opens with an introductory chapter in which the usual definitions occur relating to machines, kinematic chains, lower and higher pairs, and the like, and this is followed by a chapter which is exceedingly interesting on simple machines and machine tools.

Chapters iii. and iv. deal chiefly with mechanisms of the quadric crank and double slider crank chain forms, all those possessing important geometrical properties being grouped together. Naturally the pantograph finds an important place here, and to amplify this section there are descriptions of the copying lathe and also a machine on the same principle for drilling square and hexagon holes. In a future edition it might be worth while to insert, in a suitable place, an account of the epicyclic trains which form an essential part of some machines for turning nuts and bolts to a practically perfect square or hexagon section.

The next two chapters deal with velocity and acceleration diagrams, and we are sure that all students of mechanism will feel greatly indebted to the author for the clear manner in which he has presented this part of the subject. The remainder of the book deals with gear wheels, non-circular wheels and cams, and these are discussed on the usual lines. There is also a section devoted to gear-cutting machinery, which gives an interesting account of this special branch of machine tool work.

It is somewhat remarkable that no place is found in the book for the consideration of so fundamental a subject as the degrees of freedom possessed by a body and the applications which follow from a recognition of these principles in geometrical slides and clamps, such as are described in Thomson and Tait's "Natural Philosophy." Ignorance of these fundamental principles has been one of the most fruitful causes of bad design in mechanism.

The illustrations are mainly line drawings, exceedingly well adapted for descriptive purposes, and with a few exceptions the photographs of machinery are clear and distinct. A series of numerical examples at the end of the book will be of much value to students.

The author has succeeded in writing a valuable text-book on mechanism which will repay a careful study by engineers and others who wish to obtain a knowledge of something more than the elements of this branch of science. E. G. C.

PRACTICAL ELECTROCHEMISTRY.

Practical Methods of Electrochemistry. By F. Mollwo Perkin. Pp. x+322. (London: Longmans and Co., 1905.) Price 6*s.* net.

ELECTROCHEMICAL methods, both of analysis and preparation, have in recent years undergone such rapid development, and have reached such a degree of importance, that systematic instruction in their employment has become an indispensable part of the training of the modern student of chemistry. This book, therefore, forms a welcome addition to the ordinary laboratory manuals.

After a general account of electrical magnitudes and units, measuring instruments, and electrolytic apparatus, the author gives practical instructions for electrochemical analysis. The conditions for the quantitative electrodeposition of the individual metals are first discussed; then follows a section on quantitative oxidation and reduction at the electrodes, and, finally, directions are given for the separation of metals from mixed solutions of their salts. The last and longest section of the book deals with preparative electrochemistry. The primary subdivision of the subject is into the preparation of inorganic and of organic compounds, the latter section being treated in three chapters on organic electrolysis, reduction of organic compounds, and oxidation of organic compounds respectively.

The practical instructions are on the whole adequate and accurate, so that the student could acquire with little assistance a sufficient acquaintance with the working methods of electrochemistry. Whilst the book is satisfactory in this, the most important, feature, it shows in other respects many signs of hasty composition, which greatly detract from its value. For example, there are frequent evidences of haste in the treatment of electrical units. In the table on p. 9 the heading of the last column but one is "electrochemical equivalent per coulomb in mg. per sec."; the words "per sec." are not only superfluous but misleading. On p. 29 we find "1 kilowatt=101.93 kilogrammeters," and "1 horse-power is 75 kilogrammeters," where the words "per second" should have been added in both cases. Nothing is more detrimental to clear thinking on the part of the student than slipshod statements of this kind. Again, in the table of "useful data" on p. 286 we find "1 kilowatt=1000 watt-hours," and "volt × amperes = watts." Such data are the reverse of useful. A curious batch of mistakes is to be found on pp. 231–232. It is stated on p. 231 that the electrolyte for the preparation of diethyl succinate is "*acid* potassium or sodium malonate" instead of "*ethyl* potassium or sodium malonate." On the same page we twice find "*diethyl adipic acid*" instead of *diethyl adipate*, and on the succeeding pages a similar error

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